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Physiology and the transition from hunting to farming in ants

Jonathan Z. Shik, Ernesto Gomez, Juan C. Santos, Mike Kaspari, Jacobus J. Boomsma, William T. Wcislo

Most ant colonies are comprised of workers that cooperate to harvest resources and feed developing larvae. Around 50 million years ago, attine ants adopted an alternative strategy, harvesting resources used as compost to produce fungal gardens. While fungus cultivation is considered a major breakthrough in ant evolution, the associated physiological consequences remain poorly understood. Combining lab and field experiments, we use phylogenetically-informed comparative analyses to test for metabolic and nutritional transitions across millions of years of evolutionary diversification corresponding to: 1) the transition to attine colony-farms from ancestral hunter-gatherer colonies ca. 50 MYA, and 2) the adoption of a specifically 'domesticated' (gongylidia-producing) cultivar lineage by the 'higher' attines ca. 20 MYA. We find two major metabolic transitions. First, colonies of the earliest 'lower'-attine farmers shifted significant fractions of biomass from ant tissue to fungus-gardens and transitioned to lower mass-specific metabolic rates. Second, the transition to higher-attine cultivation was associated with increased colony metabolism, and metabolic scaling approximately identical to that observed in hunter-gatherer ants. We next explored the nutritional consequences of the farming transition. We first tested whether the shift from protein-rich to carbohydrate-rich diets, seen when humans adopted agriculture, also applied to the attine ants. We did this by analyzing the nutritional composition of resources harvested among hunting and farming colonies in a diverse tropical-forest ant community. We next used lab experiments to test whether true domestication has yielded cultivars that extract composted nutrients (supplied by ants) more efficiently as to allow better colony performance. We propose that replacing live storage tissue in the form of ant biomass with fungal mutualist biomass provided energetic and nutritional advantages that may have contributed to the further adaptive radiation of the attine lineage, and we outline critical assumptions that, when tested, will help link physiology, farming efficiency, and colony size.